

NOTICE

U.S. Department of Transportation
Federal Aviation Administration

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Cancellation

Date: 10/22/97

SUBJ: Enhanced Ground Proximity Warning System (EGPWS)

1. PURPOSE. This notice provides interim guidance for certificating an enhanced ground proximity warning system.
 2. DISTRIBUTION. This notice is distributed to the branch level in the Washington headquarters of the Aircraft Certification Service, and to the section level in all Aircraft Certification Directorates and Aircraft Certification Offices, with limited distribution in the Flight Standard District Offices, General Aviation District Offices, Air Carrier Division, and Aeronautical Quality Assurance Field Offices.
 3. BACKGROUND. Federal Aviation Regulations sections 121.360 and 135.153 require the use of approved ground proximity warning systems on certain airplanes. Until recently these requirements were met by installing TSO-C92 approved systems. Now a manufacturer, Allied Signal, is developing and promoting an enhanced ground proximity warning system (EGPWS) which adds two enhancements to the basic TSO-C92 GPWS: a Terrain Awareness and Display System, and a Terrain Clearance Floor.
 4. SYSTEM OVERVIEW. The system operates by accepting a variety of airplane parameters as inputs, applying alerting algorithms, and providing the flight crew with aural alert messages and visual annunciations and displays in the event that the boundaries of any alerting envelope are exceeded. The algorithms for the enhancements are independently partitioned from the basic TSO-C92 GPWS algorithms.
 - a. FUNCTION: The intended function of the EGPWS is to further improve the available alerting times to flightcrew in the event of potential inadvertent controlled flight into terrain (CFIT). The EGPWS may include a display system which will provide information of terrain relative to the aircraft's altitude for situational awareness purposes. Multiple alerting levels should be provided.
 - b. TERRAIN AWARENESS ALERTING AND TERRAIN AWARENESS DISPLAY SYSTEM: The terrain awareness alerts use information provided by either the Flight Management Computer (FMC) or Global Positioning System (GPS) and terrain database stored in the EGPWS computer. The EGPWS computer then uses aircraft position, performance and configuration data to calculate an envelope along the projected flight path of the aircraft and compares that to the terrain database. If there is a potential conflict, the system provides
- Distribution: A-W(IR)-3; A-X(CD)-4; A-FAC-O(ALL); Initiated by: AIR-130
A-FAC-2,3,4 (LTD), AMA-220 (1 copy)

appropriate voice alerts. As an optional feature, a display of the terrain can be viewed on either a weather (WX) radar display, Electronic Flight Instrument System (EFIS) display, or other compatible display screen. This feature is considered the terrain awareness display. Terrain within certain vertical distances of the aircraft is displayed in various color densities (currently limited to green, yellow and red; these colors currently available on the weather radar display).

c. TERRAIN CLEARANCE FLOOR: The EGPWS also provides a terrain clearance floor(TCF) which adds an additional element of protection to the standard GPWS warning modes. It may create a decreasing terrain clearance envelope around the nearest airport as the aircraft approaches the runway. The TCF alerts may be based on aircraft location, nearest runway center point position, radio altitude, or other sensors.

5. CERTIFICATION REQUIREMENTS.

a. The certification requirements included herein apply only to the enhanced features of the EGPWS, any interface with the basic TSO-C92 GPWS, and the interface with other aircraft systems. If residing in the same line replaceable unit and using the same electronics hardware (e.g. microprocessors, data busses ,etc.) the software of the EGPWS must be independently partitioned from the basic TSO-C92 GPWS. The basic system must comply with TSO-C92, whichever version for which the EGPWS applicant has an authorization. All modes of the basic TSO-C92 GPWS must be demonstrated.

b. Until such time as specific design requirements are defined and a TSO is developed for enhanced ground proximity warning systems, any such system shall be installed via the STC or TC process. First time approvals should involve the manufacturer/applicant providing detailed systems description and design features that can be verified by the ACO certification engineer and project pilot. Flight testing should concentrate upon the adequacy of the interface, basic functionality of the system, location and visibility of the display, adequacy of the visual and aural alerts, day and night lighting, ease of use and understanding of the terrain display, and potential interference with other installed equipment. In general, each mode of operation of the system should be evaluated in flight. Upon receipt of an application for the installation of an EGPWS, notify AIR-130. AIR-130 must keep abreast of the progress of this concept and accumulate information for the purpose of developing a future TSO for enhanced ground proximity warning systems.

c. The software for the enhanced features must be developed in accordance with RTCA DO-178B, Software Considerations in Airborne Systems and Equipment Certification, or a FAA accepted equivalent. The most significant aspects of the enhanced features are the terrain database stored in the EGPWS computer and the algorithms used by the EGPWS computer. Coupled with this are the evasive maneuvers that will be employed to avoid terrain.

In accordance with paragraphs 2.2.1 and 2.2.2 of DO-178B, the software for the enhanced features should be developed to level C. However, in accordance with paragraph 2.2.3 of DO-178B, a software level does not imply the assignment of a failure rate for that software. Thus, software levels or software reliability rates based on software levels cannot be used by the system

safety assessment process as can hardware failure rates. Failure rates for the system will be no greater than 10^{-4} . This includes unannunciated failure or malfunction (false warning) of the EGPWS aural or visual "pull-up" warnings.

d. The applicant must demonstrate that the accuracy of the position of the aircraft relative to the terrain is sufficiently adequate to preclude creation of a hazardously misleading situation. The accuracy of the system is dependent in large part on the accuracy of its navigation source. The applicant must demonstrate that the accuracy of the EGPWS navigation source is suitable for each phase of flight (enroute, remote/oceanic, terminal, and approach) for which approval is sought. The EGPWS navigation source may be the same as the primary navigation system for the airplane. If such is the case, it is expected that the EGPWS will be suitable for use when the primary navigation system is approved for the specific operation. In other words, when the flightcrews are predicating an operation upon the use of the approved navigation system, it is expected that the EGPWS will be capable of providing useful situation and alerting functions.

e. The applicant should specify the basic approval status of the navigation system with which the EGPWS will interface. Where applicable, use of TSO and Advisory Circular approval status is recommended. Areas of operation or other factors which adversely affect navigation performance to the extent that the EGPWS will be unreliable or potentially misleading must be identified. Flightcrew procedures to disable or otherwise not use the EGPWS (if necessary) must be identified.

f. If the terrain display system is designed to be used only as an optional system to the EGPWS, i.e. the possibility of failure is no greater than 10^{-4} , it cannot be used as a primary navigation system. However, it may be integrated within a primary navigation system. The FAA expects the pilot to adhere to the ATC flight plan clearance using the primary means of navigation while monitoring the terrain display for enhanced terrain awareness. The FAA also expects EGPWS's to be especially useful during off route vectors in the terminal area and when conducting non-precision approaches. Consequently, if used properly, the system (by itself) should not create a hazardously misleading situation. It can create nuisance and false alarms. Nuisance alarms should be minimized and false alarms should be no greater than 10^{-4} .

g. Since some terrain data currently are not available, it may be years before a complete database is developed. It may be impossible to perform 100 percent verification of the accuracy of the terrain database. There currently are no specific FAA certification standards for airborne terrain databases. To ensure there is no erroneous data that could have misleading information, the software which operates the database should be developed in accordance with RTCA DO-178B, Software Considerations in Airborne Systems and Equipment Certification, or a FAA accepted equivalent. The applicant must present the development and methodology used to validate the database process and verify it. The applicant should demonstrate the accuracy and

resolution of the database as suitable for their intended operation. The DO-200, Preparation, Verification and Distribution of User-Selectable Navigation Database, may be used as a guideline. The process should at least show how raw data is utilized, how it will be implemented into the database, and how it will be verified. In the Instructions for Continued Airworthiness,

§23.1529 and §25.1529, the applicant must indicate when the database needs to be updated and how to implement this.

h. Alerts must be clear, concise and unambiguous. If there is a failure mode in which the display may be inoperative but the EGPWS is operative or vice versa, some type of annunciation should be provided to the flight crew of the failure mode; e.g. “EGPWS display inop”, “EGPWS inop”, etc. This annunciation must be clear, unambiguous and distinguishable from other failures. The alerting system should be consistent with the basic alerting philosophy of the design of the GPWS.

i. The EGPWS as currently proposed by the applicant makes use of existing aircraft display systems such as the weather radar or the EFIS. However, while developing the EGPWS presentation format for the terrain awareness information, the applicant should address the following topics.

(1) Human Factors: The applicant should provide human factors support for their decisions regarding the display presentation. Evaluation by pilots should verify that the data supports a conclusion that the display as presented does not have human factors that would cause human error or have pitfalls, such as display perceptual or interpretive problems. There should also be some unambiguous annunciation that the selection of the display is in the terrain mode rather than the weather (WX) mode. The purpose of the terrain display is to enhance the pilots terrain situational awareness. It should be readily available and easy to interpret. It should be fully compatible with the alerting system logic so that the two systems (display and alerts) complement each other.

(2) Colors for Terrain Display: Color standardization is desirable for this type of presentation to minimize flight crew confusion of the various available colors that may be used to present the terrain on the display. It is very important for the terrain display to use a color format that will allow the pilot to readily determine whether the terrain of interest presents an impending threat to the aircraft. It is also important to distinguish between a significant reduction in the safe terrain separation that normally exists when operating on an Instrument Flight Rules (IFR) flight plan and a projected flight path that will result in a CFIT event. These two situations have distinctly different hazard levels and the alerting philosophy should take that into consideration. This system should not necessarily emulate GPWS. The initial alerting logic should not only alert the pilot to the nature of the problem, but should be designed to obtain a prompt and appropriate response so that a final warning alert should not be necessary. Voice alerts are usually associated with Time Critical Warning Systems. If voice is used, a pilot response is usually required. The display colors (without an alert in progress) should support easy understanding of the terrain situation. When an alert occurs, the terrain colors may change to enhance situational awareness and to help elicit the proper response.

(3) Pop-Up Switching Mode: If provided, the pop-up display should be designed so that it is very evident that the pop-up mode has been selected. The switch back to the original mode of operation should be easily accomplished. Procedures for enabling the pop-up mode for only one crew member (if provided) should be evaluated.

(4) Inappropriate (Nuisance) Alerts. The applicant must show that the alerting algorithm will not cause caution or warning alerts when the airplane is operated normally. Maximum normal descent rates and level off technique to be considered are:

<u>Altitude (feet Above Ground Level)</u>	<u>Rate of Descent (feet per minute)</u>
0-1000	1000
1000-2000	2000
2000-3000	3000

Maximum level off using an altitude lead equal to 10 percent of the rate of descent (e.g., 200 feet lead at 2000 fpm) should be used.

j. The applicant should make an evaluation to determine any limitations of the system and how they will affect aircraft operations. Any limitations affecting operations shall be included in the airplane flight manual supplement (AFMS). The applicant should provide instructions in the Limitations Section of the AFMS that include the following procedures and limitations:

Normal Procedures:

- When an EGPWS CAUTION occurs, adjust the airplane flightpath until the CAUTION alert ceases.
- If an EGPWS WARNING occurs, immediately initiate and continue a climb which will provide maximum terrain clearance or similar approved vertical terrain escape maneuver, until all alerts cease. Only vertical maneuvers are recommended, unless operating in visual meteorological conditions (VMC), and/or the pilot determines based on all available information, that turning in addition to the vertical escape maneuver is the safest course of action.

* Caution *

The Terrain Display is intended to serve as a situational tool only, and may not provide the accuracy and/or fidelity on which to solely base terrain avoidance maneuvering decisions.

Limitation Section:

- Navigation is not to be predicated upon the use of the terrain database display.
- Pilots are authorized to deviate from their current air traffic control (ATC) clearance to the extent necessary to comply with an EGPWS warning.

Information contained in the Limitation Section:

- The Terrain Display is intended to serve as a situational awareness tool only, and may not provide the accuracy and/or fidelity on which to solely base terrain avoidance maneuvering.
- The EGPWS data base, displays, and alerting algorithms currently do not account for man made obstructions.

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